ENGINEERING STUDY

Reducing Lead Contamination and Exposure on Military Firing Ranges Through the Practical Application of Ballistic Containment Systems

(FORTH EDITION)

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FORWARD

The first edition of this document was published in August of 1997. Since that time a great deal more test and evaluation has been done by both the military and private sector in the area of bullet containment systems discussed herein. This revised document is intended to highlight the extent and quality of these new findings and present them in a manner that the information may be reviewed and used by others in the design, construction and/or remodeling of indoor and outdoor firing ranges.

The U.S. Marine Corps; The Marine Corps Logistics Base, Barstow (MCLBB); and the Maintenance Center at MCLBB does not endorse any particular commercial manufacturer of bullet trap systems. Any references contained herein by the author that may appear to be favorable to any manufacturer should not be construed by any party as an endorsement by the author of any particular manufacturer of bullet trap systems, but rather an overall endorsement of this newer bullet trap technology.

PURPOSE

In today's environment of increasing pressure within the Department of Defense (DOD) to meet ever more stringent environmental requirements in an equivalent manner to the private sector, it has become necessary to assess the issue of reducing or eliminating lead contamination at military firing ranges. It is in this spirit of searching for solutions to decreasing the overall effects of this environmentally dangerous element that this study has been conducted. The information that follows is intended as a guide for understanding the causes and effects of general lead contamination and for choosing or analyzing different types of Ballistic Containment Systems (BCS) intended to reduce or eliminate lead contamination.

HISTORICAL BACKGROUND[1]

For decades, the presence of lead in the environment has been widespread and uncontrolled, beginning with lead smelting factories and continuing to the present day with the manufacture of glazed pottery, batteries, leaded gasoline, and firearms ammunition. Only recently has it been acknowledged that the presence of lead poses a threat to public health serious enough that it warrants government control.

In 1971, the Environmental Protection Agency (EPA) began enforcing the Lead Based Paint Poisoning Prevention Act, which restricts the amount of lead used in paints. Seven years later, EPA set the National Ambient Air Quality Standards, which served as the primary mechanism to reduce the content of lead in gasoline. However, even with these standards and other controls, the residue of lead in food, water, and soil can elevate a person's Blood Lead Level (BLL) of lead to unacceptable levels.

LEAD

The U.S. Environmental Protection Agency (EPA) classifies lead as a highly toxic heavy metal. It exhibits no biological benefit in the body[2]. When a person inhales or ingests lead, it is absorbed into the bloodstream. Once lead is in the body, it becomes very difficult to remove. Continual exposure to lead results in the accumulation of lead in the body, and measurable amounts of lead exposure can accumulate over a lifetime.

The EPA has determined that lead poses a serious health hazard to everyone who comes in contact with it. Unfortunately, individuals who work with and around firearms have entirely ignored the harmful effects of lead up to this time. Therefore, firearms range personnel, and those individuals using firing ranges, must take precautions to control all unnecessary exposure to this highly toxic element. For most people involved in shooting, just knowing the hazards of lead is a primary responsibility; taking the necessary precautions to minimize unnecessary exposure is a duty.

EFFECTS OF LEAD ON THE BODY

A simple look into the overall near and long term effects lead contamination has on the human body is in order to understand the seriousness of this problem.

Approximately 6 percent of all lead ingested or inhaled is immediately deposited in the blood or soft body tissues, such as the kidneys, brain, or other vital organs. The remaining 94 percent is more deeply deposited in bone matter. Unfortunately, the body mistakes lead for calcium. In doing so, it presumes that, once deposited, the lead needs to be stored forever.

The body does, however, break down lead so that it can be removed. The time required for this process is measured by the term "half-life", which means the amount of time the body needs to excrete one-half of the total accumulation of stored lead.

Lead in the bloodstream and in soft body tissue has a half-life of approximately 30-40 days and is excreted from the body through urine, bile, sweat, hair, and nails. However, lead deposited in bone has a half-life of approximately twenty (20) years. That is, one-half of the lead dosage absorbed by the body through only one exposure and deposited in bone matter would still be present in the body after a time-lapse of twenty (20) years.

EXPOSURE TO LEAD THROUGH FIREARMS

The exposure to lead on firing ranges (military or civilian) occurs as soon as a shooter pulls the trigger on a firearm. This action causes the primer of the cartridge in the weapon's chamber to explode, which - in turn - ignites the main powder charge. At this point, a respirable cloud of lead particulates is expelled from the cartridge primer into the air, with minute particles of lead dust spraying the shooter's hands, face, and clothing.

With exposed lead types of projectiles, minute lead particles also shear off from them as the projectile travels through the barrel of the weapon. In jacketed ammunition with exposed lead bases, minute particles are shed from the small exposed base area. When the projectile leaves the barrel, a second cloud of contaminants, in the form of the

muzzle blast, bursts into the air. These contaminants contain particles of lead and other chemicals from the projectile and the residue of unburnt powder and burnt powder gasses. Then, as the bullet travels through the air and strikes the impact area, another contaminated cloud rises if the projectile strikes a solid object causing it to break up, releasing small particles of lead dust into the air.

When shooters inhale these various clouds of contaminants, lead particles travel directly into their lungs and are quickly absorbed from there into the bloodstream. The blood then transfers this inhaled lead into soft body tissue and bone. Heat from smoking, sweating, or physical activity accelerates this process.

Lead can also settle on the skin and hair, and in turn, be absorbed through the pores of the skin. If lead particles reach the mouth, they can be ingested directly into the digestive system.

Exposure increases when it is time for the individual to clean-up, because handling empty casings can result in lead being transferred to the skin, or to clothing and other garments from where it will eventually find its way into the body. The actual cleaning process for the weapon also removes much of the remaining lead in the barrel and lead particulates from other parts of the weapon and transfers it to the cleaner's hands. Oils and solvents used to clean and lubricate weapons cause the natural oils in the skin to evaporate, leaving dry skin and open pores through which the lead can more easily pass.

SYMPTOMS OF LEAD POISONING

The numerous symptoms of lead poisoning mimic various diseases, often making diagnosis confusing and difficult. Most commonly, individuals experience abdominal pain, fatigue, nausea, subtle mood changes, headaches, constipation, irritability, and depression. More seriously, muscle pain, muscle weakness, weight loss, impotence, convulsions, anemia, and renal (kidney) failure may also occur with increased lead levels in the body.

TESTING FOR LEAD

Testing for lead can be performed in several ways. The BLL test detects recent exposure to lead but does not provide information regarding long-term or past exposure. The BLL measures the quantity of lead in micrograms per deciliter of blood, written as ug/100 dL, that is, micro-grams of lead per 100 deciliters of blood.

The Occupational Safety and Health Administration (OSHA) standards[3] state that the median blood levels for adults should be about 15 ug/100 dL; children and pregnant women should have blood levels below 10 ug/100 dL. For reproductive health, the blood level should stay below 30 ug/100 dL. OSHA recommends removal from the workplace of any employee whose BLL measures 40 ug/100 dL or higher.

In order to determine deeper exposure, the zinc protoporphyrin (ZPP) test can be performed in conjunction with the BLL. Lead interferes with the absorption of iron into the blood, which is needed to transport oxygen, thereby allowing zinc to replace the iron. The

ZPP measures the amount of zinc in the blood, which remains elevated longer than the BLL. The normal range for the ZPP is 0-100 ug/100 dL. An elevated ZPP indicates concentration in the bone marrow.

The only effective test used for bone lead levels is the disodium edetate (EDTA) chelating agent test. EDTA, a solution administered intravenously, bonds with the lead in bone and clears it from body compartments so that it is excreted through the urine. EDTA both tests and treats an individual, but medical personnel use it only in extreme cases of lead poisoning because of potentially harmful side effects.

SPECIAL LEAD CONTAMINATION RISKS

In males, high levels of lead can decrease the sex drive and cause sterility. Lead can also alter the structure of sperm cells, thereby causing birth defects.

Pregnant women are especially vulnerable to rapid absorption of lead, along with calcium, from the blood into the bone. This rapid lead migration occurs due to hormonal changes caused by pregnancy. Of greater danger, in pregnant women, lead passes unimpeded through the placenta to the fetus, potentially causing miscarriages of the fetus and/or birth defects.

Tragically, children are more vulnerable to lead toxicity than adults. Children exposed to lead may manifest slow learning, mental drifts, slight retardation in development, hypertension, and behavioral problems, while excessive blood lead levels can seriously and irreversibly damage a child's brain and nervous system during crucial development years. Because the symptoms mirror those of many childhood diseases, many doctors do not test for lead exposure.

PRECAUTIONS ON THE FIRING RANGE

Precautions can be taken both on and off the range to protect shooters, instructors, and their families from the effects of lead poisoning. Administrative controls and good hygiene are two necessary tools. In addition, all shooters and instructors should practice the following "do's and don'ts" of range safety.

- Don't smoke on the range:
  Smoking any type of tobacco products on the range should be prohibited to prevent acceleration of inhaled lead into the blood stream and ingestion of lead transferred from hands to the cigarette, cigar, etc.

- Don't eat on the range:
  Lead dust on hands and face can be ingested through contact with food. Airborne lead expelled from the weapon can also contaminate food.

- Don't collect fired brass in hats:
  Many shooters use their hats to collect spent brass; this contaminates the

hat with lead particles. When the hat is placed back on the head, the lead is deposited into the hair and absorbed into the skin. Providing boxes for the brass prevents this practice.

- Do be aware that face, arms, and hands are covered with lead particles:
  Shooters and instructors should wash thoroughly with cold water and plenty of soap. Cold water is preferred because warm water enhances the absorption of lead by opening the pores of the skin. If no water is available, shooters should consider carrying a box of wet handwipes or a bottle of cool water and a washcloth for this purpose.

- Do be aware that hair and clothes are still contaminated:
  Shooters and firearms instructors should wear an outer garment, such as a jumpsuit or coveralls, or change clothes before going home. Contaminated clothes should not be cleaned by blowing, shaking, or other means that dispense lead into the air. To prevent cross-contamination, range clothes should be washed separately from the family's regular laundry. Families with infants should be particularly careful, since infants are most vulnerable to lead contamination. Changing to clean clothing before leaving the range prevents recontamination of the hands and any contamination of the family vehicle.

- Do change shoes before entering residence:
  Shoes can also transport lead into the home. Shoes should be left at the door to prevent tracking lead onto floors and carpets. As an alternative, disposable shoe coverlets can be used while firing and cleaning, then discarded when leaving the range. Ordinary vacuuming does not remove lead from the home, but redistributes it by blowing it into the air to be inhaled and/or resettled onto the carpet.

- Do avoid physical contact with family members until after a shower, shampoo, and change of clothes:
  Lead can be transferred by casual contact. Family and friends should not be hugged or kissed until after a shower and a change of clothes. Any physical contact should be avoided while the shooter is still in range clothing.

REDUCING INDOOR FIRING RANGE CONTAMINATION

Most indoor ranges have a greater lead dust contamination problem than outdoor ranges due to the closed environment. There are two general areas where lead contamination occurs:

- At the firing line from primer ignition and muzzle blast.
- At the terminus end - the bullet trap - from projectiles striking the trap and breaking up.

In spite of these problems, range personnel can institute several controls to lower the amount of lead dust in firing ranges from these two major areas.

First, lead controls from the firing line end of the range:

The careful choice of ammunition is one such control for lead. Non-jacketed ammunition produces the most lead dust and fumes. Jacketed ammunition produces the least contaminates. Shotgun shells produce more airborne lead dust than any handgun round. Currently, many ammunition manufacturers, and DOD, are working to develop lead-free ammunition. Until sufficient lead free ammunition is available, precautions should be taken.

Another method toward control of airborn lead is through proper firing range ventilation. Ventilation requirements have been established by the National Institute of Occupational Safety and Health (NIOSH)[4]. This NIOSH standard calls for an average ventilation air flow velocity of 75 feet per minute (held within 15%) average on the empty range. This air velocity value has consistently provided adequate compliance with all federal standards established for airborne inorganic lead concentration limits. When a ventilation system has been properly designed and properly executed, lead concentrations are consistently maintained below the action level of 30 micrograms per cubic meter (30 ug/m3) in an area where the limit shall not exceed 50 micrograms of lead per cubic meter (50 ug/m3) of air over a time weighted average of eight hours as measured at the respiration zone of the shooters and the range officer when firing from the firing line. Ventilation should provide for an even flow of air across the entire width and height of the range. The exhaust duct system should be constructed in a fashion that evenly extracts the supply air from the range and exhausts it through a filtering system to eliminate lead contamination immediately outside the firing range. The exhaust fan and filter system should be designed to allow for adequate flow across the filter media. The exhaust fan should be sized so as to allow for sufficient operational static pressure at the desired volume of air flow. The filter media should be sufficient to satisfy the federal exhaust emission levels established under EPA 40 CFR 50.12 (1.5 Micrograms of lead per cubic meter quarterly).

Indoor ranges should not be carpeted, since lead dust settles and contaminates the rugs. Sealed concrete or a similar media is most desirable for floor designs. Floors should be cleaned by vacuuming or washing contaminants into an industrial treatment/capture facility. The best vacuum to use for lead would be a high-efficiency particulate (HEPA) vacuum with a 3-stage particulate air filter.

Because water cannot be treated for lead contamination, personnel should use water sparingly to remove lead when cleaning ranges. If water is used for lead removal, minimizing the amount of water used will result in less pollution. Range maintenance employees should wear disposable coveralls and air purifying masks while cleaning and/

or repairing indoor ranges that show signs of lead contamination.

Second, and most importantly, lead controls from the terminus end of the firing range:

Airborn lead particulates can be greatly reduced or eliminated entirely through the judicious selection and use of a modern bullet containment system. This is the primary thrust of this study. Plans have been in the long term development stage for several years to build a new Small Arms Test Firing Range to facilitate the armament programs being done at the Marine Corps' Multi-Commodity Maintenance Center at Barstow, California. This facility, when completed, would service the Marine Corps' Pacific Theater small arms workload and such other armament workload as might be addressed from other Federal agencies. Due to changes in environmental regulations concerning airborne lead in recent years, a primary element of the range design that must be considered is the bullet containment system - or backstop - used in the terminus end of the range. Traditional methods to stop projectiles at the terminus end of a firing range have tended to be very low-tech and inexpensive. In the past, these systems used a strike or smash plate of steel which stopped the projectile or deflected it into a secondary material such as sand or water. These types of systems, although functional, resulted in the introduction of relatively large amounts of lead into the range air due to their causing the catastrophic break-up of projectiles at impact. There are several companies which provide more modern methods of projectile - or bullet - containment which prevent lead eruption from expended projectiles[5]. One or more of these products may be used to effectively reduce the amount of lead introduced into the range atmosphere.

DISCUSSION

In order to aid in the decision making process in selecting a bullet trap system (also known herein as: *bullet containment system(s)* or *trap(s)*) for use in the new Marine Corps Small Arms Test Firing Facility, located at the Marine Corps Logistics Base (MCLB) in Barstow, California, an analysis of the various commercially available/procurable systems was conducted. This analysis focused upon the effectiveness and usability of the various trap designs in meeting the functional and operational characteristics required by MCLB Barstow. This was determined to be necessary due to a high degree of unresolved controversy regarding the effectiveness and usability of different types of bullet traps.

It became apparent when research was begun that there were a limited number of commercially made bullet trap designs available to choose from. This limit seems to stem from the long past history of this area of ballistics being so low-tech that users most commonly made their own traps from easily obtainable local materials. Everything from dirt and sand, to water, old logs, railroad ties and cast away tires have been used. None of these are acceptable in light of new efforts to contain or eliminate lead contamination.

All traps found and observed use some type of friction as a primary projectile decelerant. Previous published studies[6,7] which attempted to identify the types of bullet traps available and how they operate refer to types of traps as either friction or deceleration. This statement/position is basically scientifically inexact. If a projectile is

discharged at velocity in vacuo, it will continue unabated indefinitely. Thus, we see that even the introduction of ordinary atmospheric gases applies friction which eventually slows, then stops, a projectile's flight. Thus, the science of physics allows that all methods used in these bullet traps, thus far, decelerate projectiles by the use of friction. Some simply apply more friction than others. For example, a projectile's use of centrifugal force and rubbing against a steel plate is no less friction, by definition, than a projectile rubbing against chunks of rubber in a straight line. These previous documents, although a valuable source of general information, have limited use as they have not addressed actual use or testing data or attempted to examine the most useful bullet containment system(s).

Since the publication of the first edition of *this study*, improvements have been made concerning the design, construction and use of rubber chunk type traps. The revision of this study has sought to capture the essence of these product improvements. All of the commercial systems we researched and evaluated, and a description of their basic characteristics, are listed here alphabetically by vendor name:

GENERAL DESCRIPTION OF SUITABLE COMMERCIAL BULLET TRAP SYSTEMS:

Action Target:

General Description: Metal trap. Referred to as a Total Containment Trap, or TCT. This trap has steel plates on top and bottom set at an angle of 12 degrees from horizontal to deflect bullets into the trap. Upon entering the trap, bullets strike a series of angled plates oriented in a circular shape which direct them into a collection canister. Steel plates are affixed to the trap with bolts to facilitate removal/ replacement. The traps sit on a level concrete base.

Ammunition Capacity: Up to 7.62 X 51mm.

Expended Projectile Capacity: Manufacturer's estimated capacity of the strike plates before requiring replacement is 250,000 rounds.

Ballistic Technology Inc.:

General Description: This system uses Shock Absorbing Concrete (SACON). SACON is made somewhat like ordinary concrete, using steel or polypropylene fibers as reinforcement rather than gravel. This reduces the density from 150 pounds per cubic feet to 60 to 90 pounds per cubic feet. The material is poured into pre-formed molds determined by the user. It requires twenty-eight (28) days to cure. The material can be recycled by crushing the concrete, removing the spent bullet fragments and re-casting the concrete.

Ammunition Capacity: Up to 7.62 X 51mm.

Expended Projectile Capacity: Manufacturer's estimated capacity is 10,000 rounds before requiring recycling.

Berleburger Schaumstoffwerk Gmbh:

General Description: This trap uses preformed sheets or blocks of recycled polyurethane and rubber granules. This material, in its sheet form, can also be used to cover ceilings and floors to defeat ricochets.

Ammunition Capacity: Handgun only.

Expended Projectile Capacity: Manufacturer's estimated capacity is 10,000 rounds.

Capito & Assenrnacher:

General Description: This trap is a box shaped granular friction trap constructed with an armored steel backing and plywood sides to form a box shape, filled with granular rubber. The trap is covered with a front of polyurethane sheets and recycled conveyor belts. The trap requires a level concrete pad.

Ammunition Capacity: Up to .50 caliber.

Expended Projectile Capacity: Manufacturer's estimated capacity is 25,000 rounds.

Caswell International Corp.:

General Description: This description applies only to custom ordered versions of the company's model LE7500R product. This trap is constructed by installation of a light steel support backing structure (std. is 10 ga.) set at an approximate 38-40 degree angle. On this structure is placed a bed of *Grantex* ™ (the proprietary name for their media product). The *Grantex* ™ is then covered over with sheets of a permeable rubber. The *Grantex* ™ is placed in a pre-determined depth according to desired bullet caliber. The depth is determined by negotiation with the customer or by customer supplied specifications. For common use of occasional .50 BMG caliber up through larger calibers such as 25mm, depths in excess of fifty (50) inches are used. When cleaning of spent projectiles is required, it is accomplished by removing the rubber media and then scooping up the bullets for recycling. This company now provides this cleaning service as an added service when desired.

Ammunition Capacity: Determined by media depth. Standard is suitable for occasional .50 BMG caliber. Traps have been made that stop 25mm rounds.

Expended Projectile Capacity: The manufacturer recommends frequent cleaning - intervals of 50,000 rounds or less.

Falcon Shooting Ranges, Llc:

General Description: Metal trap. This trap is virtually identical in construction to the Savage Snail Trap (see Savage entry below) without the liquid injection system or the conveyor belt removal system.

Ammunition Capacity: Up to .50 caliber.

Expended Projectile Capacity: Manufacturer's estimated capacity is 250,000 rounds before replacement of the strike plates are required.

Range Masters, Inc.:

General Description: The TEC system consists of a set of large blocks molded from shredded, recycled tires in a matrix of Kevlar reinforced bonding mixture. The blocks weigh approximately 60 pounds each and measure about 30 x 12 x 9 inches. The trap consists of blocks placed on an inclined platform which is protected from oncoming rounds by ground baffles made of the same blocks as the bullet trap. The blocks look similar to oversized cinder blocks. The fired round penetrates the front of the block, shedding velocity until it hits one of the recovery channels, where it falls into the collection tray. Recovery channel positions may be manufactured according to the ammunition type. Intact bullets may be recovered and recycled by emptying the recovery tray at the base.

Ammunition Capacity: Up to 7.62 X 51mm

Expended Projectile Capacity: Manufacturer's estimated capacity of the blocks is 10,000 to 20,000 rounds before rotating the blocks becomes necessary.

Savage Range Systems, Inc.:

General Description: Metal trap. This trap has steel plates on top and bottom set at an angle of 12 degrees from horizontal to deflect bullets into the trap. A pump driven injector introduces a fine spray mix of water and water-soluble oil at the point of entry into the deceleration chamber to coat the strike plates and the introduced bullet. The bullet spins in a vertical plane around the deceleration chamber until it looses its velocity and slides backward to drop through a slot into a collection tray. The sprayed liquid is recycled back through the system by pumping through a holding reservoir. Steel plates are bolted onto the deceleration chamber for easy removal and replacement. Traps sit on a level concrete base. The projectile collection trays - if used - must be emptied at 25,000 rounds.

Alternatively, a conveyor belt system can move expended bullets into a collection drum for easier removal.

Ammunition Capacity: Up to .50 caliber.

Expended Projectile Capacity: Strike plates are anticipated to last for about 250,000 rounds.

Societa Fra.Sa:

General Description: This trap is an Elastomeric Granular Screen. It is constructed with loose rubber granules lying against a support structure back and a conveyor belt bottom. Bullets enter the granules, lose their velocity and stop. The conveyor belt operates daily to bring the granules and bullets to a complex sifting/ vacuum system. The vacuum dumps granules (minus the bullets) at the top of the granules pile. Bullets generally remain intact, making recycling relatively easy. Granules may require disposal as hazardous waste.

Ammunition: Up to 7.62 X 51mm.

Capacity: Manufacturer's estimated capacity is 100,000 rounds before replacing the granules becomes necessary.

Shooting Ranges International, Inc.:
General Description: Metal trap. This trap has four angled hardened steel plates per firing position that funnel bullets into a vertical aperture of a helical deceleration chamber. Once introduced, the bullets spin in a horizontal plane until they lose velocity and drop into a collection container. The traps sit on a level concrete base.

Ammunition Capacity: Up to 7.62 X 51mm.

Expended Projectile Capacity: The initial strike plates are anticipated to last for 500,000 rounds before requiring replacement.

Super Trap ™ Bullet Containment System:

General Description: Chunk rubber trap. This trap is constructed by installation of a thick armored steel support backing structure set at an approximate 35 degree angle. On this structure a bed of large recycled rubber chunks (herein after also known as *media*) is placed in a pre-determined depth according to customer wishes or desired bullet caliber. The media is only made from clean recycled rubber taken from truck tires. It contains no debris, threads, cord materials, or other non-rubber substances. The media is coated with calcium carbonate as a fire retardant. The commonly used media depth is about thirty (30) inches for up to occasional .50 BMG caliber, to an excess of fifty (50) inches for

much larger calibers or heavier use. When cleaning of spent projectiles is required, it is accomplished by vacuuming up the rubber media with a truck mounted type vacuum and then scooping up the bullets for recycling. This company now provides this cleaning service when necessary as a part of the original trap purchase. The media has a lifetime guarantee.

Ammunition Capacity: Determined by media depth. Standard trap is suitable for occasional .50 BMG caliber. Traps can be made that stop 30mm rounds.

Expended Projectile Capacity: The manufacturer has demonstrated a capacity of 1,500,000 rounds per firing lane before cleaning but advises more frequent cleaning - on the order of 500,000 rounds per firing lane.

INVESTIGATIONS

The new Marine Corps Small Arms Test Firing Range is indoors, therefore, the Marine Corps' Engineering Department at MCLB examined and evaluated new indoor firing ranges - or newly remodeled firing ranges - that had been constructed in recent years or were under construction (outdoor ranges were also evaluated) as an evaluation tool (for the sake of caparison, some outdoor ranges were also visited). The preferred method was to visit ranges that had seen some degree of normal usage, but some new structures were also examined for comparison purposes. The new Marine Corps facility is a full 100 meters in length from firing line to target and capable of the high volume firing of fully automatic military weapons up to .50 BMG caliber; possibly larger. Weapon caliber that will address the trap is an important consideration.

The 1997 examination of new and used military facilities revealed two indoor facilities constructed in recent years similar in use requirements to our intended facility. Both of those facilities use "old fashioned" bullet containment technology. One of these facilities is located at the Marine Corps Logistics Base in Albany, Georgia and the other is located at Picatinny Arsenal; The U.S. Army Armament Research and Development Facility in Dover, New Jersey. The facility at Albany, Georgia has a 100 meter range with a locally built water trap. The operators there expressed regret that some other type of system was not originally used as they experienced some major problems in the past which led to their decision to use the water trap now in place.

The second facility, at Picatinny Arsenal, has two elements, one is a 100 meter range similar in design concept to our own range design. It uses an indoor-berm type of arrangement using many tons of sand. It is expected that this system too, will soon pose an environmental problem.

The firing range examples found to be most similar to military firing ranges are some operating police department ranges and some privately owned shooting club firing ranges. A couple of examples of each were found and also examined.

EXAMINATION

Of the newer police and privately owned shooting club firing ranges found to date, there were two desirable types of products used in these ranges as bullet containment systems to reduce indoor lead contamination. The more traditional type of these systems found in use was called a *Savage Snail Trap* and is made by Savage Range Systems, Inc.; a division of Savage Firearms in Westfield, Massachusetts. This trap (described above) is of metal construction. Two newer types of systems were found using the rubber media chunks. They were made by: *Caswell International Corp.* located in Minneapolis, Mn and *Super Trap ™ Bullet Containment Systems* a company located in Temecula, California.

Several locations were found with installations of the chunk rubber-type trap systems to visit, examine and test in the local area. Some were new, some had intermediate use and some had been in use for some time. Interviews were also conducted with users of these types of traps at more remote locations we were unable to visit, most notably the Naval Surface Warfare Center at Crane, Indiana, who have had a new bullet trap installation recently retrofitted to their old facility.

COMPARISON

In making comparisons for the purposes of evaluations, it was arbitrarily decided that the *Snail Trap* type of system would represent the latest type of the older metal trap technology while the chunk rubber traps would represent the newer thought in bullet trap design. Between these two types of systems (metal trap and chunk rubber trap) the following initial items were compared (not in order of importance): initial purchase cost, long term maintenance requirements and cost, lead containment ability, hazardous waste disposal issues and system durability and longevity. The first comparison reveals the following:

Metal-Type Traps:

- Initial Cost: An initial estimate based on our preliminary range design was in excess of $120,000 dollars for our location.

- Long Term Maintenance Requirements and Cost: The system contains pumps, motors and conveyor systems subject to long term wear and failure. This equipment places an additional electric use burden on the overall operating costs of an unknown degree. The system requires a circulated cooling and lubrication liquid which becomes hazardous waste. Evaporation of the liquid is expected to occur which will require regular checking and topping-off of the system fluid levels. The manufacturer suggested that high volume use would require the regular movement and rotation of firing stations to avoid accelerated wear of the steel strike plates. The strike plate system would still have to be completely replaced at approximately 250,000 round intervals. The system life would be shortened if large

quantities of .50 BMG caliber ammunition is used.

- Lead Containment Ability: Lead containment is in question. Long use of exposed lead type projectiles does leave some lead deposits rubbed onto the surface of the strike areas from projectiles which leads to lead fragmentation and splatter. Obstructions in the trap proper also contribute to this problem and more rapid degradation than desired has been observed.

- Hazardous Waste Disposal Issues: As already mentioned, the cooling/ lubricating fluid used in some of these systems is a hazardous material after being exposed to lead and must be disposed of as such if it is replaced, which some users have reported doing. Also, the strike plates are eventually contaminated and worn out and must be replaced and disposed of as hazardous waste. Systems with dust collection schemes also produce hazardous waste in the form of dust and some of that dust migrates out of the system through seam flaws, both causing contamination issues.

- System Durability and Longevity: The system strike plates wear out and have to be replaced at approximate 250,000 round intervals. The cooling/ lubricating fluid in liquid containing systems must be replenished and/ or replaced at regular intervals. Pumps, drains, circulating plumbing, conveyors, motors and associated equipment must be addressed with periodic maintenance, repair and replacement, some items of which are lead contaminated and require special handling. All of these cause additional cost and range down time; some of which may not be planned or acceptable.

Chunk Rubber-Type Traps:

- Initial Cost: A formal estimate based on our finished design was approximately $48,000 from one of the companies for our location.

- Long Term Maintenance Requirements and Cost: Occasional surface grooming of the berm may be desirable (but not required) in the form of policing trash and smoothing the outer surface with a large rake. This can easily be done by range personnel at minimal cost. Projectiles must be periodically removed from the bottom of the trap. This is expected to occur at an approximate low of 50K rounds to a high of 1M round intervals per firing lane (depending on contractor selection and cleaning agreements). Expended projectiles are mined and sold as a solid recyclable material (***not*** hazardous waste). This would necessitate an easily planned down-time with the work performed by the contractor. Rather than hazardous waste disposal the mined lead is sold as scrap metal and the funds could be kept in local Morale, Welfare and Recreation type activities or returned to the local activity in other ways. In this way, proceeds of the recycling can be

shared with the government, eventually paying for the entire cost of the trap. (The ballistic media of one vendor is warranted for the life of the installation).

- Lead Containment Ability: Lead containment within the material has, thus far, been observed by the government to be 100% of the projectiles striking the material. Projectiles stop relatively deep within the chunk rubber material. One company will only claim a somewhat less containment ability - 99.5% or better - due to a reasonable consideration for projectiles that miss the trap or for projectiles that strike the ground or other barriers before reaching the trap.

- Hazardous Waste Disposal Issues: The durability of chunk rubber type media used in these traps significantly exceeds the life span of materials used in steel type trap systems. The material may, in some cases, be expected to last for the life-span of the trap itself. This significant increase in durability over metal type traps makes it unlikely that any of the rubber material will have to be disposed of as hazardous waste during the life of the trap. However, should the ballistic media ever need to be removed or replaced a lead leaching test would have to be performed to determine if the residual lead level is such that it would have to be handled as a hazardous substance. However, it should be noted that a sample test of this type done on an existing installation showed no reportable lead levels.

- System Durability and Longevity: The system is very low-tech, nearly as passive to use and maintain as plain soil. If constructed in accordance with the recommendations contained herein, it should give many years of trouble free service and eventually pay for itself in recycling.

TESTING

There was an initial concern by some involved parties that the actual functioning of the types of chunk rubber traps being evaluated might not meet manufacturers claims or that some considerations may have been overlooked by the manufacturers or investigators. There were further suppositions made by some personnel within *both* the Department of the Navy and Department of the Army that assumed that these types of chunk rubber traps would catch fire as a matter of course from the mere friction of impacting projectiles. Our investigation has determined, without reservation, that those fears were without merit. However, the initial investigation was directed at determining if those fears had any grounds in determinable fact, however remote they may be. It was, therefore, decided to test these rubber chunk systems and visit as many installations as possible to observe the function in a generic way - without regard to a particular manufacturer. In addition, conferences were held with individual users to determine their degree of satisfaction with the products they purchased and the manner and extent of their use. Further, it was decided to conduct our own extensive tests to determine the suitability of this technology for military or government use. A test and evaluation chunk

rubber type system was supplied to the Marine Corps to facilitate the government's evaluation of rubber bullet trap technology.

(NOTE: Refer to enclosures 2 and 3 for a complete breakdown of the test firing details performed at MCLB Barstow to date. These charts show the types of ammunition used and the results of firing the ammunition into the trap. Testing was so successful that further testing was seen as a waste of resources)

Visits were made to a number of installations where the *Super Trap* ™ system was being used and to one installation where a system made by the *Caswell International Corp* was in place. In addition, a large evaluation product and a small test box containing the media material was provided to the government by the *Super Trap* ™ company for intermittent and repeated test and evaluation on site. The test products are rectangular structures of different sizes; one is approximately three feet wide, four feet tall and four feet deep while the second is approximately a two foot cube. We were invited to shoot at these test items with as much ammunition as we wished in any type we wished. The manufacturer went so far as to invite the government to apply 25mm Target Practice (non-tracer) rounds to the trap. We declined the offer to shoot 25mm projectiles, however, a private contractor has fired 30mm rounds into a *Super Trap* ™ product successfully and a new *Caswell International Corp.* installation done under Navy specification at the Naval Surface Warfare Center (NSWC) in Crane, Indiana has successfully stopped 25mm projectiles as of this date. Both of these chunk rubber-type traps successfully demonstrated their ability to stop both tracer and incendiary ammunition without incident (although continual use of chemically hot projectiles is not recommended by either vendor).

As mentioned above, initially there was a concern that the material might be sensitive to heat to the point of being a fire hazard, however, this concern has been eliminated during our tests. A test firing at MCLB Barstow of two-hundred rounds of .50 Caliber BMG Armor-Piercing Incendiary ammunition into the ballistic media in the test product was accomplished and the material would ***not*** catch fire. There was some smoke and some small surface burning of the incendiary chemical itself, but it *failed to ignite the rubber media*. In point of fact, the material could be said to have suppressed the fire that the incendiary ammunition tried to start.

Further, tests with a very wide variety of other ammunition was conducted with even better results. All regular ammunition was stopped without any problems. The worst case tried at MCLB Barstow was 400 rounds of .50 Caliber BMG ball ammunition fired at a muzzle-to-trap distance of only ten (10) feet. This test was fired in full automatic from a standard M2 Browning tripod mounted machine gun in a period of time allowing only for the changing of the belts. The material absorbed this fusillade without notable incident. Further, similar testing conducted at a later date by the NSWC at Crane, Indiana tested the following general types and quantities of strictly military ammunition in the trap: 7,000 rounds of 5.56mm, 9,200 rounds of 7.62mm, 6,000 rounds of mixed 9mm (FMJ and Hollowpoint), 1,600 rounds of .45 caliber, 250 rounds of 12 ga. shotgun (1 oz. slugs), 400

rounds of .50 BMG and 1 20mm tracer round (the tracer self-extinguished as the author had experienced when testing incendiary ammunition). Over 24,000 rounds fired total in a very short time. NSWC personnel stated that they had originally planned to test many more rounds but had calculated that it was a waste of time and money as they soon realized the trap worked amazingly well and they could recommend the technology without qualification.

CONCLUSIONS

MCLB Barstow has concluded that more use should be made of this new type of chunk rubber media bullet containment system by DOD. We are convinced that this represents the best current overall technology, if there is any consideration to be made in lead containment. The reasons for the suitability of this type of system are as follows:

- Eliminates airborne lead for easy OSHA/ NIOSH/ EPA compliance.
- Environmentally friendly, uses 95% recycled materials in construction.
- Lowest estimated cost for an environmentally compliant system.
- Passive operation, no moving parts to fail or wear out.
- Virtually eliminates fragmentation or ricochets of projectiles.
- Can fire at any angle into the stop material up to point-blank range without danger to personnel.
- Only maintenance is simple sweeping of disturbed material and infrequent surface cleaning of the system.
- Lead removing maintenance cleaning cycle time can be far better than any other type of technology examined.
- Expended projectiles are easily and safely captured whole for easy and profitable recycling.
- There is no need for special ammunition up through .50 BMG Caliber (such as frangible, light target projectiles, etc.).

These chunk rubber systems unquestionably meet or exceed every claim made of them by the manufacturers, as long as basic construction specifications are met (see recommendations). Normal caliber pistol bullets come to a complete stop in

approximately 10 inches of material with the worst cases being .50 caliber BMG Tungsten Steel Armor-Piercing rounds that penetrate approximately 22 inches on average and 25mm Rounds penetrating approximately forty (40) inches. Most amazingly, this technology introduces a new element in the use of ranges as the danger of possible ricochets are so completely eliminated that even large-caliber high-power center-fire rifles and machine guns may be fired into the material at point-blank range, at any angle, with complete operator safety. This allows test and training to ranges of zero inches, which is not possible with other systems. If anything was unusual in these findings it is that these systems so exceed the expectations of all interviewed users that it is seeing a higher level of use than originally planned. For example, one police department user originally planned the system for an indoor 25 yard pistol range, but it works so well they now shoot every caliber of weapon up to high-power .30 caliber center-fire rifles into it without incident.

We have also determined that a desirable feature is to construct a below-grade trench in the floor to act as the leading edge of the trap. This feature extends the effective use of the trap to zero inches ground level to provide extra protection against accidental floor strikes.

RECOMMENDATIONS

We recommend that all military and other government departments and agencies use these chunk rubber-type *Bullet Containment Systems* when new ranges are being built or old ranges are being retro-fitted.

We further recommend that if more than one potential vendor is considered in a procurement action (e.g. non-sole source procurement) that a procurement specification be written to cover the deliverable design and construction materials and methods thought by the acquiring facility to be most desirable. As a minimum, we recommend that the essential requirements of any system offered should be:

- Some essential evaluation criteria: Performance to stop projectiles, long term maintenance requirements and cost, lead containment ability, hazardous waste disposal issues/necessity, system durability and longevity, and initial purchase cost.

- A requirement for a backing material made of armor or high hardness steel with equivalent steel support beams.

- Use of large-size chunk, high-durometer, clean (debris and fiber free), chopped rubber truck tires as media.

- Placement of steel backing support at an angle appropriate for the intended application.

- Use of a below-grade trench instead of a front support.
- No use of sheet rubber covering over the media (it is an unnecessary cost and adds additional unnecessary maintenance).
- Passive Operation.
- Can be fired into safely at any angle.
- Eliminate airborn lead.
- Fire retardant material added to media.
- Use of 95% recycled materials in construction.
- Eliminates ricochetts.
- Can be fired into at point-blank range.

OTHER RECOMMENDED APPLICATIONS:

During the course of these examinations it has become apparent that this same type of chunk rubber-type Bullet Containment System is also well suited for environmental remediation of existing outdoor firing ranges and the construction of new outdoor firing ranges in addition to use for indoor firing ranges as recommended in this study. As an example, there is an existing outdoor range at the Bakersfield Police Department that functions exceedingly well in the outdoor environment. It has been demonstrated (observed and measured by MCLB Barstow) that winds as high as ninety miles per hour have no effect on blowing the material away from the trap and performance as a trap system does not appear to be threatened by rain or snow. Since this type of chunk rubber system is constructed as a berm, it does not mask down range targets or give away target locations, also making it well suited for Automated Field Fire Ranges, Automated Record Fire Ranges and Combat Pistol Qualification Course Ranges.

This type of system can also be modified to make vertical indoor and/or outdoor walls in urban or shipboard simulation live fire houses such as those used in CQB and MOUT training to easily defeat and contain 5.56X45mm or larger rifle ammunition.

FOOTNOTES:

1. Reprinted and revised from: *Lead Poisoning: A Firearms Safety Hazard* By Amelia Newberry Martinez; Firearms Training Instructor; FBI Training Academy; Quantico, Virginia. Taken from the FBI Law Enforcement Bulletin, August 1993.

2. U.S. Environmental Protection Agency, *Strategy for Reducing Lead Exposures*, February 21, 1991.

3. Occupational Safety and Health Administration Standards: Occupational exposure to lead. chap. XVII, title 29, U. S. Department of Labor, sect. 1910.1025 and 1926.62.

4. HEW publication no. (NIOSH) 76-130; dated December 1975; *Lead Exposure Design Considerations for Indoor Firing Ranges.*

5. Enclosure (1) to this report. Current List of Bullet Containment System Manufacturers/Providers developed by the U.S. Marine Corps Logistics Base; Multi-Commodity Maintenance Center; Engineering Department; Small Arms Programs; Barstow, CA; 92311-5015; (760) 577-7280.

6. Report, U.S. Army Environmental Center, No. SFIM-AEC-ET-CR96195; "Bullet Trap Feasability Assessment".

7. Report, U.S. Army Environmental Center, No. SFIM-AEC-ET-CR96201; "Bullet Trap Users Guide".

ADDITIONAL REFERENCES:

1. "Closed, Transferred, and Transferring Ranges Containing Military Munitions; Proposed Rule"; Department of Defense, 26 September 1997.

2. "Military Munitions Rule: Hazardous Waste Identification and Management: Explosives Emergencies, Manifest Exemption for Transport of Hazardous Waste on Rights-of-Way on Contingpuous Properties; Final Rule" EPA, FR, Vol. 62, No. 29, page 6621, 12 February 1997, codified at Title 40 CFR parts 260 through 266, and 270. Subpart M, "Military Munitions" is in part 266.

Enclosure 1

BULLET CONTAINMENT SYSTEM MANUFACTURES/ PROVIDERS

Action Target
P.O. Box 636
Provo, UT 84603
Phone: 801-377-8033
FAX: 801-377-8096

Ballistic Technology Inc.
(Makers of Shock Absorbing Concrete: SACON)
1041 Avenue Road, Suite 4
Toronto, Ontario M5N 2C5
Phone: 416-932-0208
Fax: 416-932-0460

Berleburger Schaumstoffwerk GMBH
P.O. Box 1180
5920 Bad Berleberg, Gerrnany
US Distributor: Tennek, Inc.
972 Tapadevo Road
Bailey, CO 80421
Phone: 303-838-0922
FAX: 303-838-0924

Caswell International Corp.
1221 Marshall St. NE
Minneapolis, MN 55413
Phone: 612-379-2000
FAX: 612-379-2367

Capito & Assenrnacher
443 19 Dortmund Wichkede
44311 Dortmund
Germany
Phone: 0231 331012-0
FAX: 21925

Falcon Shooting Ranges, LLC
35 Dartmoor
Enfield, CT 06082

Phone: 860-763-5185
Fax: Same No.
Falcontrap@aol.com

Range Masters, Inc.
199 Coon Rapids Blvd.
Suite 304
Coon Rapids, MN 55433
Phone: 612-357-4104
FAX: 612-3574105

Savage Range Systerns, Inc.
100 Springdale Rd.
Westfield, MA 01085
Phone: 413-568-7001
FAX: 413-562-7764

Societa FRA.SA
Rome - Via del Giordano, 44
Italy
Phone: 59-25-560 or 59-11-936
FAX: 59-24-175

Shooting Ranges Intemational, Inc.
3030 S. Valley Vlew Blvd.
Las Vegas, NV 89102
Phone: 702-876-5444
FAX: 702-876-0327

Super Trap Bullet Containment Systems
P.O. Box 890911
27640 Commerce Center Dr. Unit 104
Temecula, CA 92590
Phone: 909-693-2322
Fax: 909-693-2433
Government Rep: Chuck Chaldekas
Phone & Fax: (619) 435-7234

Enclosure 2

AMMUNITION MATRIX FOR BALLISTIC CONTAINMENT SYSTEM TESTS

Type of Ammunition *	Firing Distance	Bullet Type	Weight - gr.	Velocity - f.p.s.	Energy - ft. lbs.
.22 LR (F)	6 in.	Lead HP	31	1550	165
9X19mm (G)	6 in.	FMJ-RN	125	1230	420
.38 Special (W)	6 in.	RN Nyclad	158	755	200
.40 S&W (E)	6 in.	FMJ-RN	165	970	345
.357 Magnum (W)	6 in.	JSP	158	1235	535
10mm (E)	6 in.	FMJ-HP	180	1055	397
.45 ACP (G)	6 in.	FMJ-RN	230	855	373
12 ga. slugs (F)	1 ft.	Lead HP	1 ounce	1760	-
12 ga. magnum 00 buckshot (F)	1 ft.	Clad Shot	1 5/8 ounce	1220	-
5.56X45mm (G)	1 ft.	FMJBTPC	62	3000	1240
7.62X39mm (E)	1 ft.	FMJ-SC	123	2320	1458
7.62X51mm (G)	2 ft.	FMJ-HP	150	2907	2815
.300 Win. Mag. (W)	3 ft.	FMJ	180	2960	3501
.458 Win. Mag. (W)	3 ft.	SP	510	2040	4712
.50BMG Ball (G)	10 ft.	FMJ-SC	660	2910	12427
.50BMG AP Incendiary (G)	10 yds.	API	650	2800	11313

* Ammunition Manufacturers: F = Federal Cartridge Co.; E = El Dorado Cartridge Corp.; W = Winchester/Olin Corp.; G = Government Issue

Enclosure 3

RESULTS OF LIVE FIRE TESTS OF BALLISTIC CONTAINMENT SYSTEM MEDIA

Type of Ammunition	Type of Weapon	Rounds Fired	Effect on Bullet	Effect on Media
.22 LR	S&W Model 63 Revolver	36	Recovered Whole	NONE
9X19mm	M9 & Glock 17	40	Recovered Whole	NONE
.38 Special	S&W 686 Revolver	10	Recovered Whole	NONE
.40 S&W	S&W 4006	10	Recovered Whole	NONE
.357 Magnum	S&W 686 Revolver	10	Recovered Whole	NONE
10mm	Custom Colt Delta Elite	10	Recovered Whole	NONE
.45 ACP	M1911A1 & Glock 21	50	Recovered Whole	NONE
12 ga. 1 oz. slugs	M500	12	Recovered Whole	NONE
12 ga. magnum 00 buck	M500	12	Recovered Whole	NONE
5.56X45mm	M16	40	Recovered Whole	NONE
7.62X39mm	Custom SKS	40	Recovered Whole	NONE
7.62X51mm	M1A	100	Recovered Whole	NONE
.300 Win. Mag.	Winchester Model 70	10	Recovered Whole	NONE
.458 Win. Mag.	Weatherby Mark IV	10	Recovered Whole	NONE
.50 BMG Ball	M2 Machine Gun, M82A1 SASR & L.A.R. Grizzly Rifle	420	Recovered Separated	NONE
.50 BMG AP Incendiary	M2 Machine Gun	200	Recovered Separated	Small fire started and self-extinguished